oncrete Highway Bridges
"Concrete for Permanence"
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CHICAGO

A concrete bridge in Wisconsin, somewhat more pretentious than most shown in this booklet, illustrating, however, that the concrete bridge is none too good for the strictly rural highway.

Concrete arch bridge, Spokane, Wash. The grounds of a private estate have been extended under this bridge and are used as a children's playground.

"No road is better than its weakest bridge," says Captain E. Z. Steever, U. S. Army. Highway bridges that will not carry the greatest load which the road itself is able to bear make the highway inefficient.

Concrete Highway Bridges

ADVANTAGES OF CONCRETE BRIDGES

CONCRETE bridges, like concrete roads, are for the traffic of today and tomorrow. Concrete bridges grow stronger as they grow older. They will not rust, rot, burn, nor deteriorate in any other way. They need no painting, no tightening of bolts, nuts or rivets, no repair of masonry joints, no periodical replacement of worn-out parts, no rebuilding after floods.

Concrete comes in for special attention in highway bridge construction today because of war's demands for other material. The concrete highway bridge makes economical use of steel in the form of rods or bars that can usually be obtained quickly.

Almost without exception, concrete bridges are lower in first cost than those built of other materials, while with respect to ultimate cost, there is no comparison. Concrete is free from those maintenance expenses that soon make other types of bridges more expensive in the end regardless of first cost.

A graceful concrete arch bridge in Bexar County, Tex.

Concrete for Permanence

WAR OPERATIONS DEMAND CONCRETE BRIDGES

Permanent highway bridges are just as desirable in times of peace as in times of war, but in the latter case they are imperative. Quick, easy movement of munitions, heavy guns and troops means highways with no weak spots —permanent arteries of intercommunication between farm and farm, city and town, state and state—highways usable and able to withstand any kind of traffic 365 days a year. Concrete highway bridges and concrete paved roads accomplish this end.

CONCRETE A HOME BRIDGE MATERIAL

Aside from the strictly commercial advantages of concrete as a

Concrete arch bridge near Binghamton, N. Y., showing simple but pleasing decorative treatment.

bridge material is the advantage that most of the materials of which concrete is made can be found either on the site of the work or near by. All that need be shipped in is the portland cement and the relatively small quantity of steel reinforcing bars or rods needed. Local labor can be used in concrete bridge construction under competent supervision. Concrete lends itself readily to various kinds of ornamentation. Decorative treatment is limited only by the skill and ingenuity of the designer and workman.

By adopting concrete for their bridges, highway officials place themselves in a position independent of extensive construction equipment, of distant markets for materials and labor, of rush conditions in distant mills or yards from which other materials must be obtained—in other words, concrete construction permits quick realization of any community's bridge needs or desires.

This booklet is intended to illustrate only the smaller types of concrete highway bridges and small culverts. The highway departments of most states have one or more standards for small concrete highway bridges and culverts. Plans and specifications for these can usually be obtained by addressing your state highway department.

A simple yet graceful concrete arch in Onondaga County, N. Y.

CAREFUL ATTENTION TO DESIGN AND OTHER REQUIREMENTS NECESSARY

It must not be supposed that any design can be adapted to or made to fit any location. The many advantages of concrete can be obtained only by consistent use of it. Every bridge location involves some special study to best meet the needs of the particular situation. De-

signs for small culverts, and for bridges up to say, 16 or 20-foot span can, in large part, be standardized for certain types. Larger and more important bridges should be designed by competent engineers familiar with or able to obtain first-hand knowledge of all conditions that are to be fulfilled.

One of the standard bridges of the Wisconsin State Highway Commission in Sheboygan County, Wis.

Concrete bridge built by Massachusetts State Highway Department near Spencer, Mass.

Principles of Construction

LOCATION

BRIDGES or culverts should be correctly located with respect to the highway and the stream. They should be on the center line of the highway. The abutment walls should be parallel to the course of the stream while the rails of the bridge should be parallel to the highway. This frequently requires a skew design for which concrete more readily adapts itself than any other type of construction. It is often

Concrete arch bridge in Randolph County, W. Va.

advisable to change the channel of a waterway for a short distance in order to secure a better approach for the stream to the bridge opening, and a better angle of crossing. The objects to be secured are, as nearly a straight course as possible on the upper side of the bridge and the same for a short distance at least on the lower side. This will reduce to a minimum danger of the bridge being undermined or its adjoining embankment being washed away by high water. In locating a bridge, due consideration should be given also to securing as nearly level and straight approaches on the highway as possible.

Concrete for Permanence

FOUNDATIONS

Large bridges should be founded on rock or on piles driven to refusal. Smaller structures may rest on good firm earth, provided footings are so spread that the pressure on the soil is well within the limits of safety.

The following table shows the safe bearing power of various soils:

BEARING POWER OF SOILS

	Supporting Power in Tons per Sq. Ft.
Rock—in thick layers, in natural bed	200
Clay—in thick beds, always dry	4
Clay—in thick beds, moderately dry	2
Clay—soft	1
Gravel and coarse sand, well cemented	8
Sand—compact and well cemented	4
Sand—clean and dry	2
Loam soils	0.5

Small concrete culvert. A standard of the Iowa State Highway Commission.

In general, foundations should extend below possible frost penetration, but otherwise need not be carried deeper than to firm bearing soil or to a depth necessary to prevent undermining.

ABUTMENTS

All bridges require an abutment on each side of the stream. The object of this is to support the main bridge structure and to retain in place the roadway embankment. Wing walls also are needed to retain the slopes of the embankment. Wing walls may be placed in a line that is a continuation of the line of the abutment, or may be set at any angle with it required by local conditions. It is best that the wing walls be monolithic with the abutment proper. In very long abutments vertical expansion joints should be placed every

One of the many small concrete highway bridges of the Minnesota highway system.

30 to 50 feet to prevent cracking of the concrete due to expansion and contraction under changing temperature conditions. It is also important that suitable drainage be provided for the fill behind the abutment.

FORMS FOR CONCRETE

Forms should be substantially built of 2-inch plank fastened to 2 by 6-inch uprights, well tied and braced inside and outside. Form sheathing should be surfaced on two edges and on the face that is to be next to the concrete so as to give the concrete a smooth surface finish. In some cases tongued and grooved boards may be preferable. There are many types of commercial steel forms on the market that

are particularly suited to small bridge and culvert construction. A list of manufacturers will be found on page 19. Care should be taken that forms are so braced and supported as not to give way under pressure of the concrete which they must sustain.

FORM REMOVAL

Forms should not be removed until all possibility of collapse of concrete that has not acquired its full strength will be prevented. No definite time can be stated for form removal. This is largely a matter of judgment on the part of the engineer or contractor resulting from long practical experience. Forms for arches should be left in place until the concrete is strong enough to be safely self-supporting.

Concrete bridge, Middleport, N. Y., carrying one of Niagara County's famed concrete highways

As a general guide it may be said that forms for abutments should be left in place at least ten days, for girders from thirty to sixty days, and for arches from thirty or more days depending upon weather and season conditions.

EARTH FILLS

Earth filling must not be placed until wing walls and abutments can safely withstand the pressure of the earth. After forms have

been removed, earth for fill should be placed in such a manner as not to cause uneven loading of the concrete. Filling should be carried on simultaneously on both sides of the bridge so as to cause an equal distribution of pressure throughout the structure.

REINFORCING

As each bridge is the subject of special design, no fixed rules can be given for reinforcing the concrete.

LOW-WATER BRIDGES

In some of the western states there have been built within the past few years what are known as low-water concrete bridges. These as a rule span streams or stream beds in which there is little water carried at any season of the year except during floods following cloud-

"Low water" concrete bridge near San Antonio, Tex.

bursts. The advantage of such bridges is that they allow an enormous volume of water, due to these sudden and heavy downpours, to flow over them, thus preventing debris from piling up against the upstream side of the bridge or in any other way stopping the waterway. Such bridges frequently serve the purpose of fords since they may safely be used by teams even when considerable water is flowing over them. The large number of such bridges successfully meeting all requirements, particularly in Kansas and Texas, gives indisputable proof of the floodproof qualities of concrete bridges.

This type of construction is one particularly adapted to those portions of the west where rainfall instead of being evenly distributed throughout any given season, comes in the form of cloud-bursts, compelling stream beds and other waterways to carry suddenly and for a brief time, enormous volumes of water.

EXAMPLE OF STANDARD 14-FOOT BRIDGE

An accompanying design for a 14-foot span concrete bridge for 20-foot roadway is from the standards of the Wisconsin Highway Commission. This is given merely to illustrate a typical design for structures of its kind. For the average location this design requires 35 cubic yards of excavation, 60 cubic yards of concrete and 3,100 pounds of reinforcing steel. An accompanying table shows excavation and materials required for various spans. These figures are based on data also taken from standards of the Wisconsin Highway Commission. They will serve as a guide for average conditions anywhere.

Concrete bridge on the Olcott-Lockport concrete road, Niagara County, N. Y.

TABLE SHOWING QUANTITIES OF MATERIALS REQUIRED IN CONCRETE BRIDGES OF SPANS 8 FEET TO 24 FEET, ROADWAY 20 FEET, AS SHOWN BY THE STANDARD PLANS OF THE WISCONSIN HIGHWAY COMMISSION.

Size	Excavation	Concrete	Reinf. Steel Pounds
8-foot span, 20-foot roadway	25 cu. yd.	42.3 cu. yd.	1910
10-foot span, 20-foot roadway	30 cu. yd.	49.8 cu. yd.	2210
12-foot span, 20-foot roadway	35 cu. yd.	56.5 cu. yd.	2720
14-foot span, 20-foot roadway	35 cu. yd.	60.3 cu. yd.	3100
16-foot span, 20-foot roadway	40 cu. yd.	68.6 cu. yd.	3540
18-foot span, 20-foot roadway	40 cu. yd.	72.8 cu. yd.	3950
20-foot span, 20-foot roadway	45 cu. yd.	81.4 cu. yd.	4540
22-foot span, 20-foot roadway	50 cu. yd.	91.9 cu. yd.	5320
24-foot span, 20-foot roadway	50 cu. yd.	98.2 cu. yd.	6360

A concrete bridge in Niagara County, N. Y., which forms a permanent link in the concrete highways of Niagara County.

Concrete for Permanence


Concrete pipe culverts are often a simple solution of waterway requirements of the highway.

Concrete Culverts

CONCRETE possesses the same advantages for culverts as for bridges. Neither concrete culverts nor bridges require maintenance, and are floodproof and permanent. Culvert construction has been very largely standardized as far as design is concerned and it is easy to determine a suitable size for any location from a table of standards showing the required size of waterway for various areas to be drained. The character of the area to be drained must be considered, that is, whether covered with steep hills, whether rolling land or flat country.

The table on the following page taken from Bulletin No. 4, Texas Engineering Experiment Station, shows the required size of waterway for various areas:


Concrete bridge on the Inland Empire Highway, Spokane County, Wash.

SIZE OF WATERWAY REQUIRED FOR VARIOUS AREAS TO BE DRAINED

AREA DRAINED	AREA OF WATERWAY NEEDED (in Sq Ft)		
	Steep Slopes	Rolling Country	Flat Country
Acres			
10	5.6	1.9	1.1
20	9.4	3.1	1.9
30	12.8	4.3	2.6
40	15.9	5.3	3.2
50	18.8	6.3	3.8
60	21.6	7.2	4.3
80	27	8.9	5.4
100	32	10.6	6.3
125	37	12.5	7.5
150	43	14	8.6
200	53	18	10.6
300	72	24	15
400	89	30	20
Square Miles			
1	127	42	25
2	214	71	43
3	290	97	58
4	359	120	72
5	425	141	85
7	548	183	109
10	716	239	143
15	970	323	194
20	1204	401	241
30	1630	543	326
50	2390	797	478
75	3240	1080	648
100	4020	1340	805

Having obtained the area to be drained, the size of culvert necessary can readily be chosen from the above table. For example, if a culvert is to carry water from 200 acres in a rolling country, then 18 square feet of waterway is required calling for a 4 by 4½ or 4 by 5-foot box culvert.

STANDARD BOX CULVERT

As an example of a box culvert the accompanying design for a 3 by 3-foot box culvert has been taken from the standards of the Iowa Highway Commission. Dimensions and details of reinforcing are shown on the plan and no further description should be necessary.

Concrete bridge in Marion County, Ind. This structure forms a link in a stretch of 18-foot concrete road.

Concrete for Permanence

CONCRETE PIPE CULVERTS

While the box culvert is a very popular form and one that lends itself readily to any local conditions to which suited, there is often advantage in using concrete pipe for small waterways, particularly if a nearby cement products plant can supply such units. A concrete pipe culvert can be installed for a cost that makes it very economical. It will neither rot nor rust. Well made concrete culvert pipe are proof against destruction by frost. Very often heavy storms break away some portion of the road, carrying out other culverts. The concrete pipe culvert properly placed is likely to stay where put. Other materials used for culverts are best when first made or placed. Well made concrete pipe grow better and stronger with age.

Some counties have successfully manufactured their own concrete culvert pipe. This practice may be followed if there is no nearby concrete products plant to supply the necessary pipe. Careful workmen can soon be trained under proper supervision to make uniformly high grade pipe. Good materials and good concrete practice are all that are needed.

Concrete bridge in Iowa. One of the standards of the State Highway Commission of that state.

Concrete culvert pipe up to 24 inches in diameter is not as a rule reinforced. The pipe walls are made thick enough to resist all loads to which they are subjected in normal use. Larger sizes are reinforced with steel in various forms. What type of reinforcing to use depends largely on individual preference. When properly hardened, concrete culvert pipe can be handled with little or no breakage. They are dependable, economical and in culverts render long service with little or no expense for upkeep.

SECTIONAL CONCRETE CULVERTS

There are several types of sectional concrete culverts which consist of precast units, either square or rectangular in section, which are assembled in various ways, notably by the shape of the particular unit which provides for interlocking adjoining ends and by metal fittings cast in place in the concrete at the time the unit is cast, these fittings being so arranged as to interlock or otherwise join with similar fittings in the abutting unit.

Reinforced concrete girder bridge, McCracken County, Ky.

BRIDGE AND CULVERT STANDARDS OF STATE HIGHWAY DEPARTMENTS

The highway department of practically every state has adopted certain standards for its highway bridges and culverts. In most cases copies of these standards, which include detailed plans and other information, can be obtained by addressing the state highway department of your state. Somewhat similar information can be secured from the Office of Public Roads, United States Department of Agriculture, Washington, D. C.

RECOMMENDED PRACTICE IN CONCRETE BRIDGE CONSTRUCTION

The Portland Cement Association has prepared a Recommended Practice in Concrete Bridge Construction which contains the essentials of specifications that represent what is today regarded as the best practice in concrete bridge work. A copy of this booklet will be sent free on request.

Concrete bridge on the Sacramento-Oregon route, Shasta County, Cal.

SOME MANUFACTURERS OF FORMS FOR CONCRETE BRIDGES, CULVERTS AND CONCRETE CULVERT PIPE

FLAT OR ARCH FORMS—
ADJUSTABLE

Mission Form Co., Dallas, Tex.
Flom Concrete Form Co., Inc., Madison, Wis.
Concrete Form Co., Inc., Union Building, Syracuse, N. Y.
The Whalen Form, E. J. Whalen, Syracuse, N. Y.
American Concrete Forms Co., Bloomington, Ill.

ADJUSTABLE ARCH

Illinois Concrete Machinery Co., Buda, Ill.
Frick Manufacturing Co., Fricks, Pa.
The Highway Culvert Form Co., Ottawa, Ill.

ADJUSTABLE ARCH OR CIRCULAR

The Merillat Culvert Core Co., Winfield, Ohio.

PIPE AND BOX

Blaw-Knox Co., Pittsburgh, Pa.
Hydraulic Pressed Steel Co., Chicago.

PIPE

Northwestern Steel & Iron Works, Eau Claire, Wis.
Pioneer Manufacturing Co., Waterloo, Iowa.
Quinn Wire & Iron Works, Boone, Iowa.
Raber & Lang Manufacturing Co., Kendallville, Ind.
W. E. Dunn Manufacturing Co., Holland, Mich.

SECTIONAL

Security Culvert Co., Minneapolis, Minn.
Hall Interlocking Concrete Culvert, Schulz & Hodgson, Chicago.

CIRCULAR AND FLAT MONOLITHIC

Martin Concrete Form Co., Ottawa, Kans.

The old and the new, showing permanent concrete bridge and the, at best, short-lived structure which it replaced.

Concrete for Permanence

FREE BOOKLETS

On the Uses and

The Portland Cement Association publishes a number of bulletins which contain information on concreting practice and other details of concrete work that will be helpful to those engaged in or contemplating various highway improvements. Among these bulletins, which can be had free on request, are the following:

Proportioning Concrete Mixtures and Mixing and Placing Concrete.

Concreting in Cold Weather.

Protecting Concrete in Warm Weather.

Facts Everyone Should Know About Concrete Roads.

Specifications for Concrete Roads, Streets and Alleys, and Concrete Paving Between Street Car Tracks.

Concrete Facts About Concrete Roads.

This temporary strueture was replaced by the permanent conerete one shown on the next page.

Concrete for Bridges

AND BULLETINS

Advantages of Concrete

Colorimetric Test for Organic Impurities in Sands.

Your Streets.

That Alley of Yours.

Concrete Highway Magazine.

Integral Curb.

How to Maintain Concrete Roads and Streets.

LET US HELP YOU

The Portland Cement Association will be glad to co-operate with highway officials, engineers, contractors or others interested in helping to solve individual highway bridge and culvert problems. We shall be glad to refer you to engineers and contractors competent to design and construct highway bridges. This service incurs no obligation and may be had for the asking.

Concrete bridge in the village of Glenview, Ill. On the opposite page is shown a structure which this one replaced.

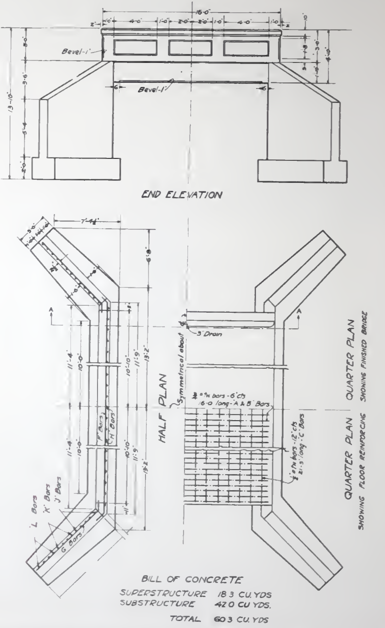
Concrete for Permanence

Two views of a concrete bridge forming a link in the Columbia River highway.

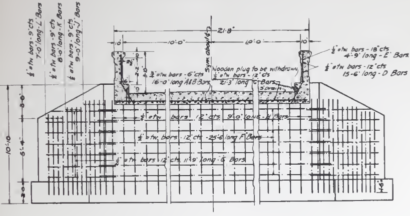
One of the many concrete bridges for which the highway system of Oregon is noted.

Concrete for Bridges

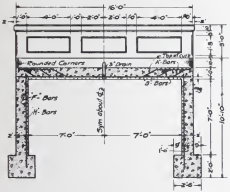
Standard Bridge
AND
Culvert Plans



Standard concrete highway bridge for 14-foot span and 20-foot roadway of the Wisconsin Highway Commission. M. W. Torkelson, Bridge Engineer.



FRONT ELEVATION OF ABUTMENT AND CROSS SECTION OF ROADWAY



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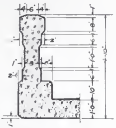


RAILING AND COPING DETAIL

-GENERAL NOTES-

Concrete to be class 'A' mixture

Round exposed edges of concrete to a 1" radius

The arrangement of longitudinal bars in floor to be as follows The 'A' bars alternate with the 'B' bars Ends are reversed for adjacent 'A' bars and 'B' bars

For each vertical foot of change in height of substructure above footing add or subtract 3.2 cu yds of concrete, add or subtract one (1) foot in length of H, J, K and L bars, add or subtract two (2) F bars and four (4) G bars, weight-170#

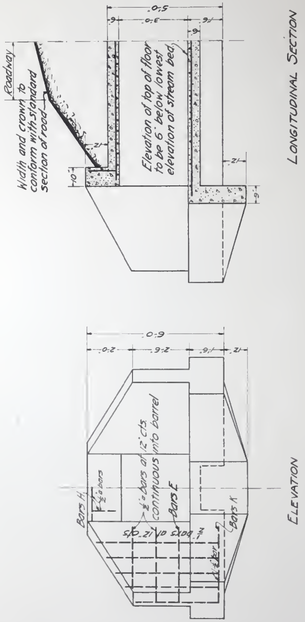
All reinforcement shall be held in place by metallic bar chairs

BILL OF BARS FOR BRIDGE COMPLETE

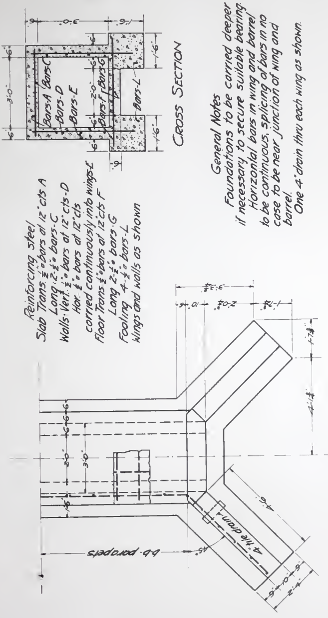
Nº	MARK	SIZE	LENGTH	LOCATION
22	A	$\frac{3}{4}$" ⌀ tw	16'-0"	Longitudinal in Floor
22	B	$\frac{3}{4}$" ⌀ tw	16'-0"	Longitudinal in Floor
22	E	$\frac{1}{2}$" ⌀ tw	4'-9"	Vertical in railing
15	C	$\frac{1}{2}$" ⌀ tw	21'-3"	Transverse in floor
8	D	$\frac{1}{2}$" ⌀ tw	15'-6"	Horizontal in Railing
14	F	$\frac{1}{2}$" ⌀ tw	25'-6"	Horizontal in Body of Abutment
28	G	$\frac{1}{2}$" ⌀ tw	11'-9"	Horizontal in Wings
46	H	$\frac{1}{2}$" ⌀ tw	9'-0"	Vertical in Body of Abutment
20	J	$\frac{1}{2}$" ⌀ tw	9'-0"	Vertical in Wings
16	K	$\frac{1}{2}$" ⌀ tw	8'-0"	Vertical in Wings
16	L	$\frac{1}{2}$" ⌀ tw	7'-0"	Vertical in Wings

Total Steel.-3100#

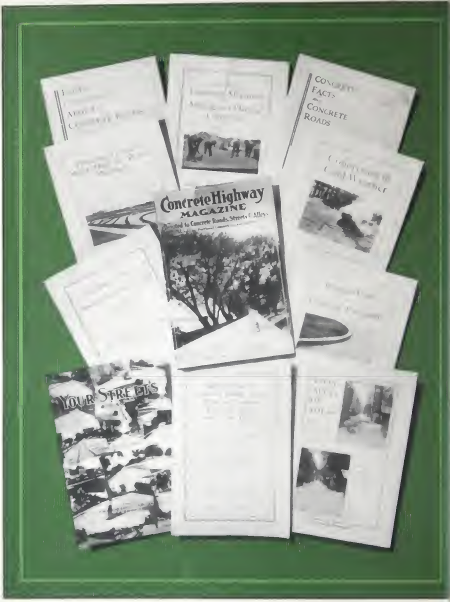
Some details and other data applying to the design shown on the opposite page.



Standard 3 by 3-foot box concrete culvert of the Iowa Highway Commission.



Some details and construction data referring to the design on the opposite page.



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